Digital Integration Of Engineering And Manufacturing

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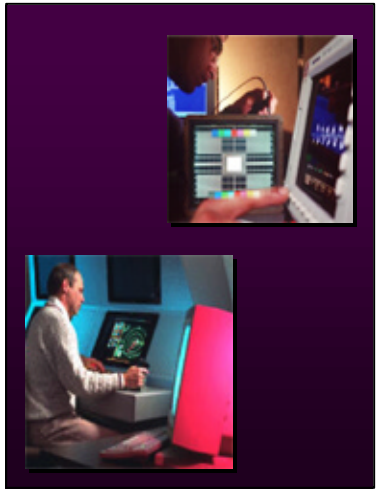
Digital Integration Of Engineering And Manufacturing

"Global Business = Global Standards"

GENERAL DYNAMICS CORPORATION

Business Segments

Combat Systems



Information Systems & Technology

Marine

Aerospace

- **Why Digital**
- **Why ISO Standards**
- **What are Those Standards**
- **Benefits**
- **Plant Program**
- **Future Plans**

DIGITAL ENGINEERING CREATES A PATH TO DIGITAL MANUFACTURING

Standard for the Exchange of Product Model Data (STEP)
Numerical Control (NC) - STEP NC

Open Modular Architecture Control (OMAC)

WHY DIGITAL MANUFACTURING ?

- **Problem**
  - **Most Product Exchange is Still Through Paper or Proprietary Data Formats**
  - **Results In Delayed Production. Rework Costs Industry an Estimated $1M per Day, Data Related Problems Cost Industry Millions**
- **Solution**
  - **Provide Digital Infrastructure**
  - **Must be Interoperable. Data is Allowed to Flow Across Dis-Similar Platforms**
- **Results**
  - **OEM's will Reduce Design to Production by Months**
  - **Suppliers Could Reduce Delivery Time by Four Months if they Received Interoperable Data from OEM's for Each New Design**
- **How**
  - **Using STEP NC and OMAC**

STEP, STEP NC AND OMAC
WHAT IS IT

- **STEP Implementation**
  - **Allows Exchange and Sharing of Product Data Among Dis-Similar Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Numerical Control (NC) Machines**
  - **Allows Exchange and Sharing of Product Data While Retaining Semantics Throughout the Product Life Cycle**
- **STEP is an International Standard (ISO 10303) that Defines the Methodology to Create Computer Interpretable Product Data Models. STEP Standards are Developed by International Working Groups**

STEP, STEP NC AND OMAC
WHAT IS IT
(CONTINUED)

- **STEP NC**
  - **Standard for the Exchange of Product Model Data, Numerical Control (STEP NC)**
  - **STEP NC is a CAM to CNC Machine Tool Interface**
  - **Complete Snapshot of All Information Required to Manufacture a Part**
- **Open Modular Architecture Controller (OMAC)**
  - **The United States OMAC Users Group is Pursuing a Common International Application Program Interface (API) Standard in Collaboration with European (OSACA) and Japanese (JOP) User Groups to Promote Open Architecture Control Development Among Control Builders. Facilitates a Whole New Means of Integration**
  - **Allows Systems to be Easily Configured, Simulated and Built from Modular Building Blocks**
  - **Adaptable for Different Platforms, Architecture is Open and Extensible**
  - **Allows "Plug In" Application Specific Implementations (Example: STEP NC)**

STEP WORKING GROUP COLLABORATION

Australia
Belgium
Brazil
Bulgaria
Canada
China
Czech Republic
Denmark
England
Finland
France
Germany
Hungary
Ireland
Italy
Japan
Korea
Lithuania
Malaysia
Mexico
Mongolia
Netherlands
Norway
Poland
Portugal
Romania
Russia
Singapore
Spain
Sweden
Switzerland
United States
Yugoslavia

OMAC MEMBER COMPANIES

END USER MEMBERS

Anheuser Busch
BP Amoco
Cargill
Caterpillar Inc.
Cummins Engine
Daimler Chrysler Corp.
Deere & Company
Delco Electronics of Delphi Automotive
Dofasco Steel
Eastman Chemical Company
Eastman Kodak Co.
El Paso Energy Corporation
Ford Motor Company
Gates Rubber Company
General Dynamics Land System
General Mills Inc.
General Motors Powertrain Group
General Motors Corporation North American Operations
Goodyear Tire & Rubber Co.
Hershey Foods Corp.
Hewlett-Packard Ink Jet Business Unit
Honda of America Mfg., Inc.
Hyundai Motor Company
Intel Corporation
Draft Foods
M&M Mars
Mckee Foods Corporation
Maximum Spindle Utilization
Michelin North America
Millennium Chemicals
Nabisco, Inc.
New United Motors Mfg., Inc. (NUMM()
Pharmacia & Upjohn, Inc.
Philip Morris USA
Pratt & Whitney
Proctor & Gamble Co.
Ralston Purina Co.
The Boeing Co.
Unilever
Westinghouse Savannah River
William Wrigley Jr. Company

OMAC
ORIGINAL EQUIPMENT MANUFACTURERS (OEM)
MEMBERS

Ames Engineering Corp.
Angelus Can Machine Co.
Brenton Engineering
Bridgeport Machines
CCL Label
Charmilles Technologies
Cincinnati Machine
Delta Systems Inc.
Douglas Machine, Inc.
Elliot Manufacturing Company Inc.
Emplex Systems
GENCOR
Huskey Injection Molding Systems
Hurco Companies Inc.
Ilapak
Ingersoll Milling Machine Co.
IWKA Pacunion GmbH
Klockner Bartelt
Makino
Markem Corporation
Mazak Corporation
Mettler Toledo
MGS Machine Corporation
Monarch Machine Tool Co.
OKUMA America Corporation
OPTIMA Packaging Group
Pacific Packaging Machinery
Priority One Packaging RA Jones & Company Inc.
Robert Bosch Packing
Rovema Packaging Machines
Sandiacre Packaging Machinery
Sasib Packaging, North America
Schneider Packaging Equipment
SIG Pack
Universal Instruments Corp.

OMAC
TECHNOLOGY PROVIDERS AND INTEGRATORS
MEMBERS

ABB Packaging Automation Div.
Acroloop Motion Control Systems
ACS Co., Ltd.
Advanced Micro Controls Inc. AMCI
Advanced Real-Time Control Systems, Inc.
Advanced Technology Services, Inc.
Alabama Technology Network
Allen-Bradley Division Rockwell Automation
Alexandria Technical College
American Robot Technologies
API Motion Inc.
Argo International
ASAP Inc.
ASAP Technology
AT&R Ingenieria
ARC Advisory Group
Automation Intelligence
Baldor Electric Company
Alluff Inc.
Beckhoff Automation
Blue Water Systems
Bosch Automation Technology
bfa
Brain International
BSQUARE Corporation
Cadence Design Systems
Cadillac Electric
CamSoft Corporation
Chesapeake Bay Systems
Cimetrix
Ci Technologies Inc.
Cleveland Motion Controls
Clone Computer Corporation
CNC Engineering, Inc.
Computer and Automation Institute
CTC Parker Automation
Cutler-Hammer
Cyberonics Inc.
Cycle Software, Inc.
Delta Tau Data Systems
DHS & Associates Inc.
Divelbiss Corporation
Entivity Inc.
e-Manufacturing Networks Inc.
E-Mation
ELAU, Inc.
Emerson Motion Control
Florida State University College of Engineering
Fru-Con Engineering
Fuji Electric Co., Ltd.
Geneer
Giddings & Lewis Automation
Gintic Institute of Mfg. Technology
GE Cisco
GE Fanuc Automation
Halley Sistemas
Hitachi, Ltd.
Honeywell Micro Switch
Human-Machine Systems
Hungarian Academy of Sciences, Budapest
Ikerlan
Indramat Division Rexroth Corp.
Industrial PC, Inc.
Intech
Intellution
Intercim Corporation
Intrinsyc Software, Inc.
James J. Childs Associates
JL Souser
Kukulu Automation
Labtech
Lawrence Livermore National Laboratory (LLNL)
LiveData, Inc.
Lockheed Martin Postal Systems
Louisiana Center for Manufacturing Sciences (LCMS)
Mantha Software
Manufacturing Automation Laboratories Inc. (MAL)
Manufacturing Data Systems (MDSI)
MDT Software
Microsoft
Middough Consulting
Mitlar Industrial Technology
Mitsubishi Electric Automation, Inc.
MotionIO
Motoman Inc.
NCME Inc.
Nematron Corporation
Nexen Group Inc.
NIST Dept of Commerce
Nortel Networks
North Coast Electric
Northwest Controls, Inc.
Numerical Control Service, Inc.
Omron Electronics, Inc.
Ormec Systems Corp.
Parker Hannifin Corporation
Phoenix Contract
Pilot Design
PMMI
Purdue University
Radi Sys
Raytheon Consulting Group
Real Time Development Corp.
Real-Time Innovations, Inc.
Real-Time Information Services
Rockwell Automation
ROY-G-BIV Corporation
RWD Technologies Inc.
S&I Process Control Ltd.
Sandia National Lab
Schneider Automation
Sebesta Blomberg & Associates
Siemens AG / Energy & Automation
Softwin GmbH
Software AG, Inc.
Sound Machine Tool Controls
SST
Steeplechase Software, Inc.
STEP Tools, Inc.
Stratus Computer
Syner4getic Micro Systems
Sysesis International
SyTech
TA Engineer9ing Co., Inc.
Telemetry Control Systems, LLC
Textron Systems
Trandes Corporation
University of California
University of Michigan
University of Southwestern Louisiana
USDATA Corporation
VarTech Displays Inc.
VDW
VenturCom
Vickers Electronic Systems
Virtual Access Networks
VMIC
WAGO Corporation
Wesco Distribution, Inc.
Wind River Systems
Wonderware
Xycom Automation
Yaskawa Electric America
Zone Automation
Zarpac Inc.

KEY FEATURE OF STEP-NC

- **STEP-NC Describes “What” Not “How”**
  - **Make this Geometry from this Stock**
  - **By Removing these Features**
  - **In this Order**
  - **With this Tolerance**
  - **And Tools that Meets these Requirements**

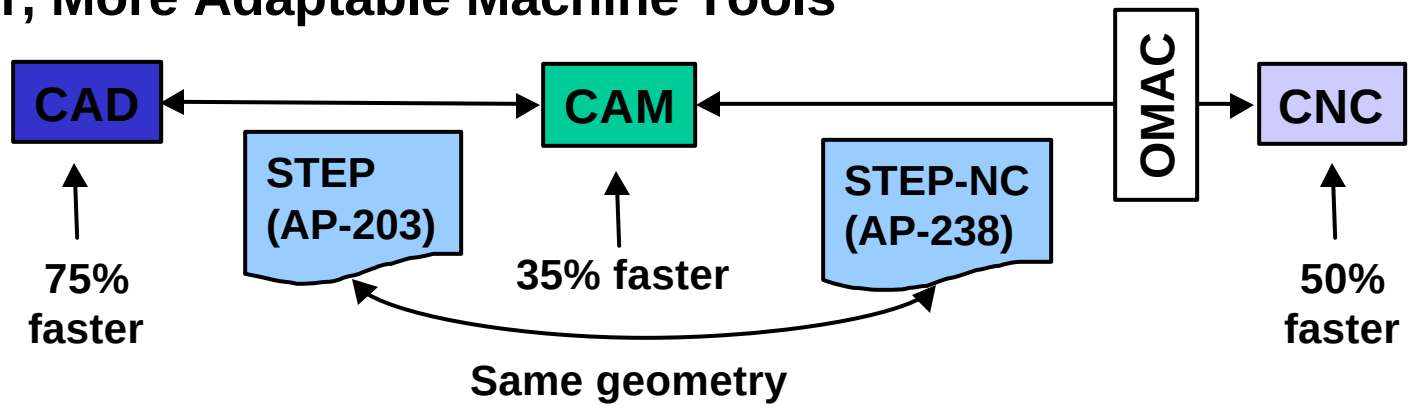
- **The Old Standard Described “How”**
  - **Move Tool to this Location**
  - **Move Tool to this Location**
  - **And so on for Millions of Commands**

KEY BENEFITS OF STEP-NC

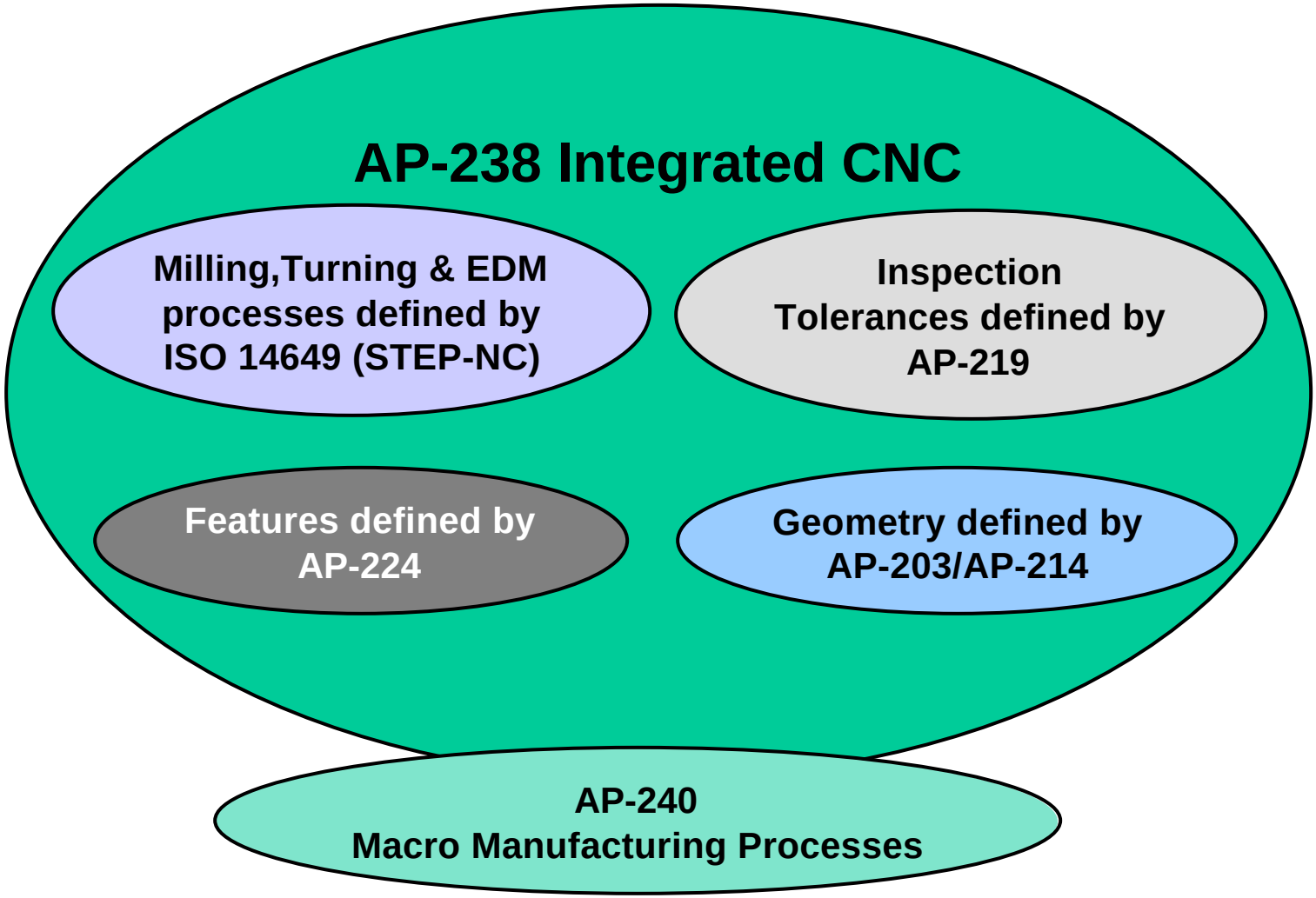
- **Fewer Drawings**
  - **STEP-NC Data is Self Documenting**
- **Quicker CAM**
  - **No Need to Describe Unnecessary Details**
- **Faster Machining**
  - **Using Intelligent Optimization on the Control**

STEP-NC

- Direct Control of Machine Tools From 3D Data
  - STEP-NC Under Development in Europe and Far East for 5 Years
  - Milling, Turning, Wire EDM, CMM Others Anticipated
- Benefits
  - 35% Reduction in CAM Planning Time
  - 75% Reduction in Number of Drawings Sent From CAD to CAM
  - 50% Reduction in Machining Time for Small to Mid Sized Job Lots
  - Elimination of 4,500+ Post Processors
  - Safer, More Adaptable Machine Tools



AP-238 – STEP IS INTEGRATED



CONSIDERATIONS

- **If Current Trends Continue**
  - **Most Machine Tools Will Be Made in the Far East, Many in China**
  - **(Today GDLS Can Buy US for $1.2M or Korean for $0.25M)**
  - **The CAM Vendors Will Expand Their Post Libraries From 4,500 to ???**
  - **In the Event of an Emergency 10,000 People May Be Trying to Port 10,000 G-code Files to 10,000 Machines With 10,000 Posts**
- **STEP-NC**
  - **Eliminates the Post**
  - **Defines a Higher Level Interface**
  - **Maximizes Flexibility of the Part Programs**
  - **Maximizes Independence From the Machine Tool Vendor**
  - **Replaces IGES and RS274D Allowing Internal and External Suppliers to Be Driven From the Same Data**

CURRENT NC PROGRAMMING USING RS274 (M&G CODES)

The standard for 50 years!

Machine-specific Part Program With Axis Data Generated by a Postprocessor

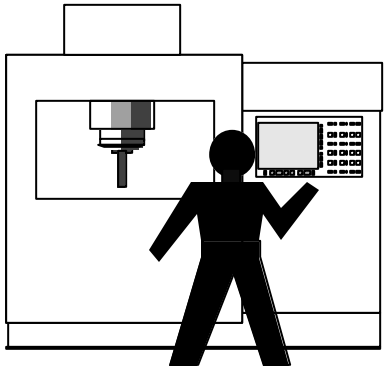
Vendor-specific Extensions of the Original Standard

Only Primitive Motion and Switch Commands

No Standardized Data Format for Spline Processing and Sophisticated NC Technology

```
%
N05    G54
N10    G00 Z10.000
N15    G91 G0 Z200
N20    T5 D1 WW
N30    G90 M5
N35    G00 X0.000  Y-150.000
N40    G00 Z5.000
N45    M08
N50    S3183.000
N55    M03
N60    F1477.000
N65    G00 X60.000  Y-150.000
N70    G00 Z5.000
N75    G00 X60.000  Y-150.000
N80    G01 Z-0.500
...
```

Ideal for Paper Tape!



STEP-NC OMAC Replaces This With a Rich, Integrated Data Format

Courtesy WZL RWTH Aachen

CAM BENEFIT

- **AS-IS Process**
  - **CAM User Receives Drawing**
  - **CAM User Converts Drawing Into CAM Model**
  - **CAM User Generates RS274D From CAM Model**
- **TO-BE Process**
  - **CAM User Receives 3D Model**
  - **Feature Recognition Used to Initialize CAM Model**
  - **CAM User Generates AP-238 From CAM Model**
- **Accelerants**
  - **Feature Recognition**
  - **Features Sent to CNC Instead of M and G Codes**

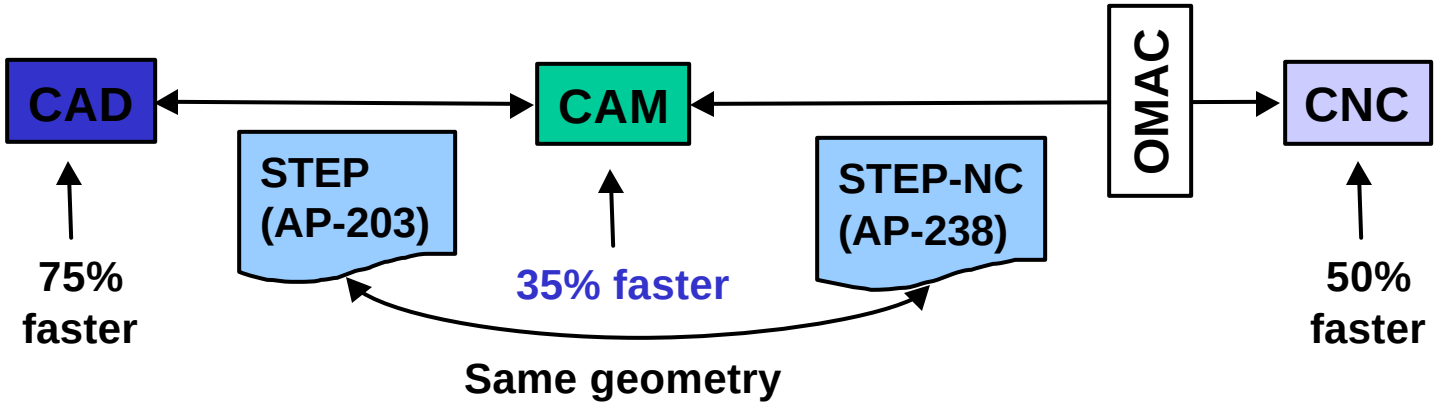
CAM BENEFIT

The Supplier Creates the CAM Plan from a 3D Product Model Instead of Paper Drawings

Estimated by Lockheed Martin

Of 13M engineering hours on Boeing 777 project an estimated 8M spent on data correction and administration

	Without STEP				With STEP	Saving
	Max	Min	Average		Average	
Hours to make a process plan	100	4	16		12	25%
Hours to replan a process plan	20	1	4		3	25%
Number of iterations			3		2	33%
Total Hours			28		18	36%



PDM BENEFIT

- **AS-IS Process**
  - **Make Drawings for Each Stage of Manufacturing from 3D Models**
  - **Annotate Drawings With Product Specifications as Text**
  - **Send Drawings to Manufacturing**
- **TO-BE Process**
  - **Send STEP-NC Data Containing AS-IS and TO-BE Model for Each Manufacturing Stage**
- **Accelerants**
  - **No Need to Make So Many Drawings**
  - **Manufacturing Gets an Electronic Product Specification**

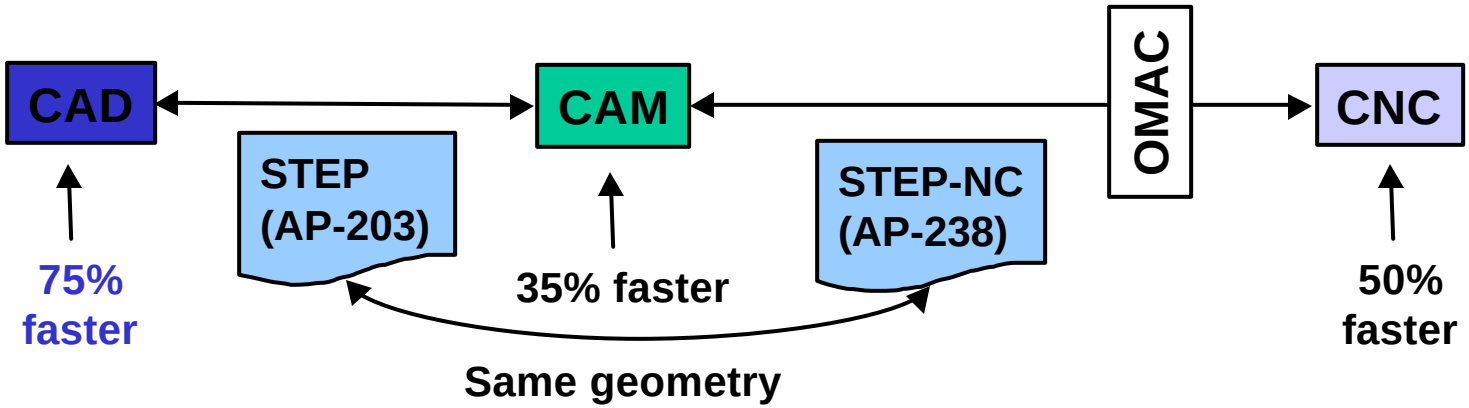
PDM BENEFIT

A 3D Model Is Sent to the Supplier Instead Of Paper Drawings

Estimated by Raytheon

For each 1 file made by design 100 are made by manufacturing – Ford Motor

	Using Drawing			Using STEP		Saving
	Max	Min	Average			
Number of Drawings per design	100	10	40		10	75%
Number of hours to make drawing	80	1	8		8	
Total Hours			320		80	75%



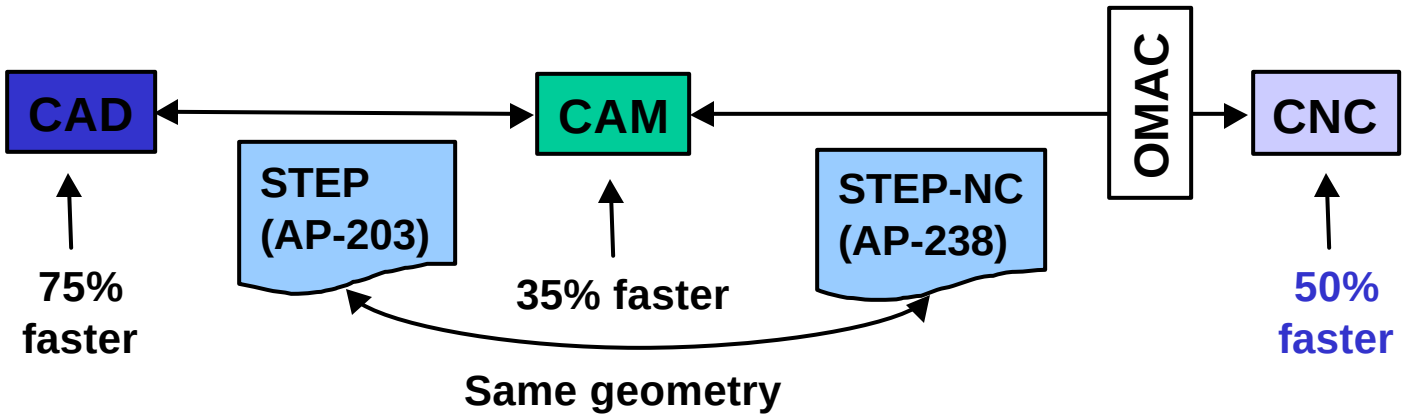
CNC BENEFIT

The Machine Computes Optimum Speeds and Feeds From Full Fidelity Geometry Information

Estimated by Cincinnati Machine

By value, 75% of manufacturing is for lots of 50 or less – Manufacturing Roadmap

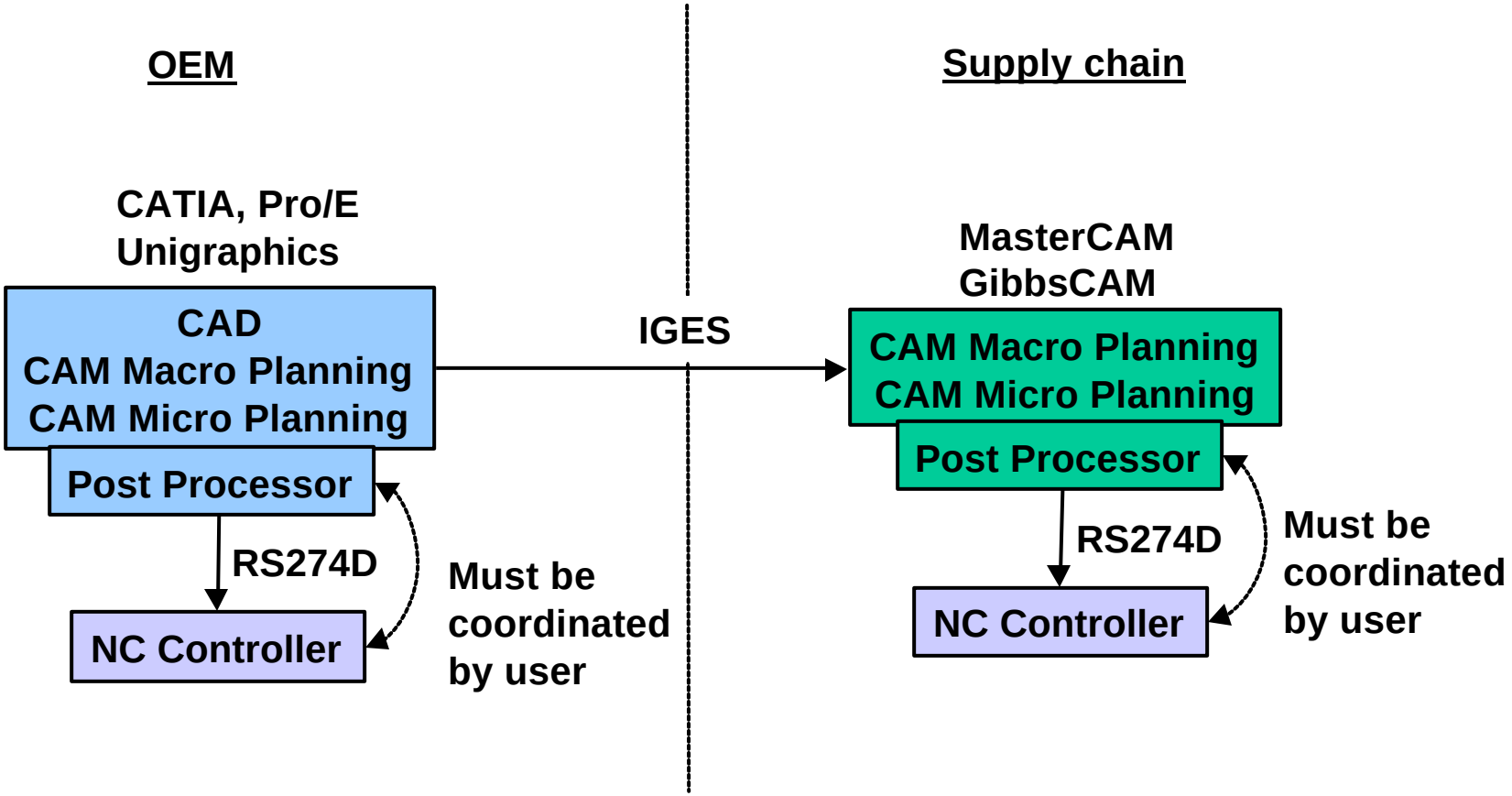
Part name	s05	s06	s09	s25	w2005
Old Mach	3-axis	4-axis	4-axis		
	4.13hrs	2.3hrs	1.18hrs	?	?
New Mach	5-axis	5-axis	5-axis	5-axis	5-axis
	1.09hrs	0.36hrs	?	0.59hrs	0.59hrs
	73.61%	84.35%			



CNC BENEFIT

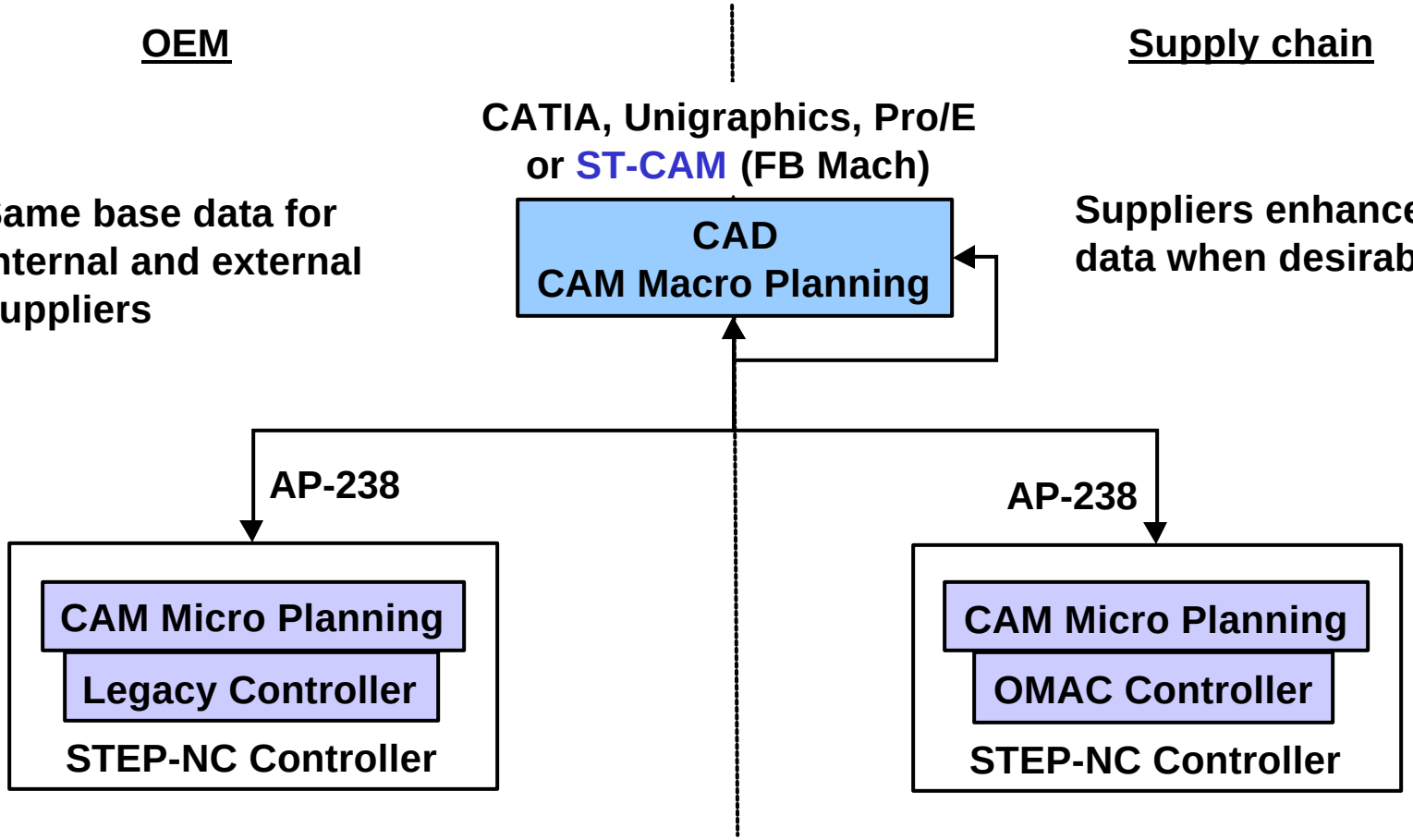
- **AS-IS Process**
  - **Machine Executes RS274D Codes With As Much Accuracy as Possible**
- **TO-BE Process**
  - **Machine Gets Complete Manufacturing Specification**
    - **Geometry, Tolerances, Tool Requirements, Fixtures, Material**
  - **Machine Computes Optimal Speeds and Feeds**
    - **Algorithms + Tool Database + Geometry / Tolerances**
- **Accelerants**
  - **5 Axis Machining and High Speed Machining Become Easier and Safer to Use So they are Used More Often for Small and Medium Lot Manufacturing**

AS-IS PROCESS



Macro Planning Is Stock Definition, Feature Selection, Process Ordering and Tool Requirements.
Micro Planning Is Tool Path Generation With Tools That Meet the Requirements

TO-BE PROCESS



Post Processor is invisible to the user.
Micro planning (tool path generation) is automatic using a CAM system integrated with a legacy or new Controller.

OBJECTIVES
GDLS STEP NC / OMAC 3 YEAR PROGRAM

- **Implement Global Standard for the Exchange of Product Model Data (STEP) Standards and Open Modular Controllers to Allow Data Exchange to and from Design and Manufacturing**
  - **Partner with the Army's National Automotive Center (NAC), STEP Tools, National Institute for Standards and Technology (NIST), Lawrence Livermore National Lab (LLNL), ARDEC/TIME, Louisiana Center for Manufacturing Sciences (LCMS), Numerical Control Service (NCS), Gibbs and Associates**
  - **Test Global Standards, Open Architecture Controller, Computer Aided Design (CAD) Systems, Computer Aided Manufacturing (CAM) Systems, and Import to Machines on the Shop Floor**
  - **Eliminate the Post and Archaic RS274 (M&G) Codes**
- **Establish a Industry Process that Shares Data Between Design, Process Planning and Machine Tool Controller**

Reduce Industry Costs by Eliminating Paper and Proprietary Data Formats

STEP NC ELECTRONIC COMMERCE
INDUSTRY BENEFITS
DEVELOP DATA INFRASTRUCTURE INTEROPERABILITY

- **Promote Dual Use Technology Investment to Integrate Commercial and Military Production**
- **Build Open Architecture Data Infrastructures**
  - **Creating Multi-Vendor Integration of Defense Data Systems (Prime, Subcontractor, Component Vendors)**
  - **Creating Interoperable Data Within Government and Government Contractor Base**
- **Reduce Costs Using the STEP 3D File Based Infrastructure**
- **Use of the Internet to Transmit STEP Data**
  - **Reduce Original Equipment Manufacturer (OEM) Production Planning and Manufacturing Control for Supply Chain by 30% or More**
  - **Reduce Supply Chain Business Costs from 10% to 40%**

STEP NC - OMAC PROGRESS
3 YEAR PROGRAM 2000 THROUGH 2002
ACCOMPLISHMENTS AS OF AUGUST 2002

- **Secured GDLS Engineering / Manufacturing 3 Year Program Commitment**
- **Secured National Automotive Center (NAC) 3 Year Program Commitment**
- **Identified the Open Modular Architecture Controller (OMAC) as the Controller of Choice**
- **Located a Bridgeport Machine (Government Furnished) at Scranton for Testing. Identified Production Test Parts**
- **GDLS Scranton Production Identified Virtual Gibbs CAM System as CAM System of Choice for Program**
- **Secured Program Commitment from Bill Gibbs (CEO) of Gibbs & Associates**

STEP NC - OMAC PROGRESS
3 YEAR PROGRAM 2000 THROUGH 2002
ACCOMPLISHMENTS AS OF AUGUST 2002

- **Formed Team with National Automotive Center (NAC) GDLS Scranton Plant, Lawrence Livermore Labs, STEP Tools Inc., ARDEC / TIME, Louisiana Center for Manufacturing Sciences Gibbs & Assoc., Numerical Control Services to Run a Parallel Production Program with the STEP Tools ATP NIST Program**
- **Team Met at the GDLS Scranton Plant to Review Bridgeport Specifications and Document Machine Readiness, Required Machine Improvements, and Task Team Members**
- **Processed Material Requests for Team Vendor Participation**
- **Concurrently Forming International Coalition for Support of STEP NC Standard as (ISO) International Standard and OMAC API Development**
- **Development of Additional Macro Process ISO Standard**

STEP NC
OMAC CURRENT STATUS

- **All Equipment and Software has been Delivered for Machine Upgrade**
- **NCS has Installed Upgraded Parts on Bridgeport**
- **OMAC Development is Now Under Louisiana Center for Manufacturing Sciences (LCMS)**
- **First Test August 2001**
- **Testing Showed Development of the Baseline for**
  - **Faster CAD to CAM Using AP 203 (Any CAD System will do)**
  - **Faster CAM to CNC Using STEP NC**
  - **No Post Processor, All CNC's will Read STEP NC**
  - **Machining Using an OMAC Controller**

Conclusion:
We have a Framework for Implementing
Faster, More Intelligent Machining

STEP NC
OMAC CURRENT STATUS
(CONTINUED)

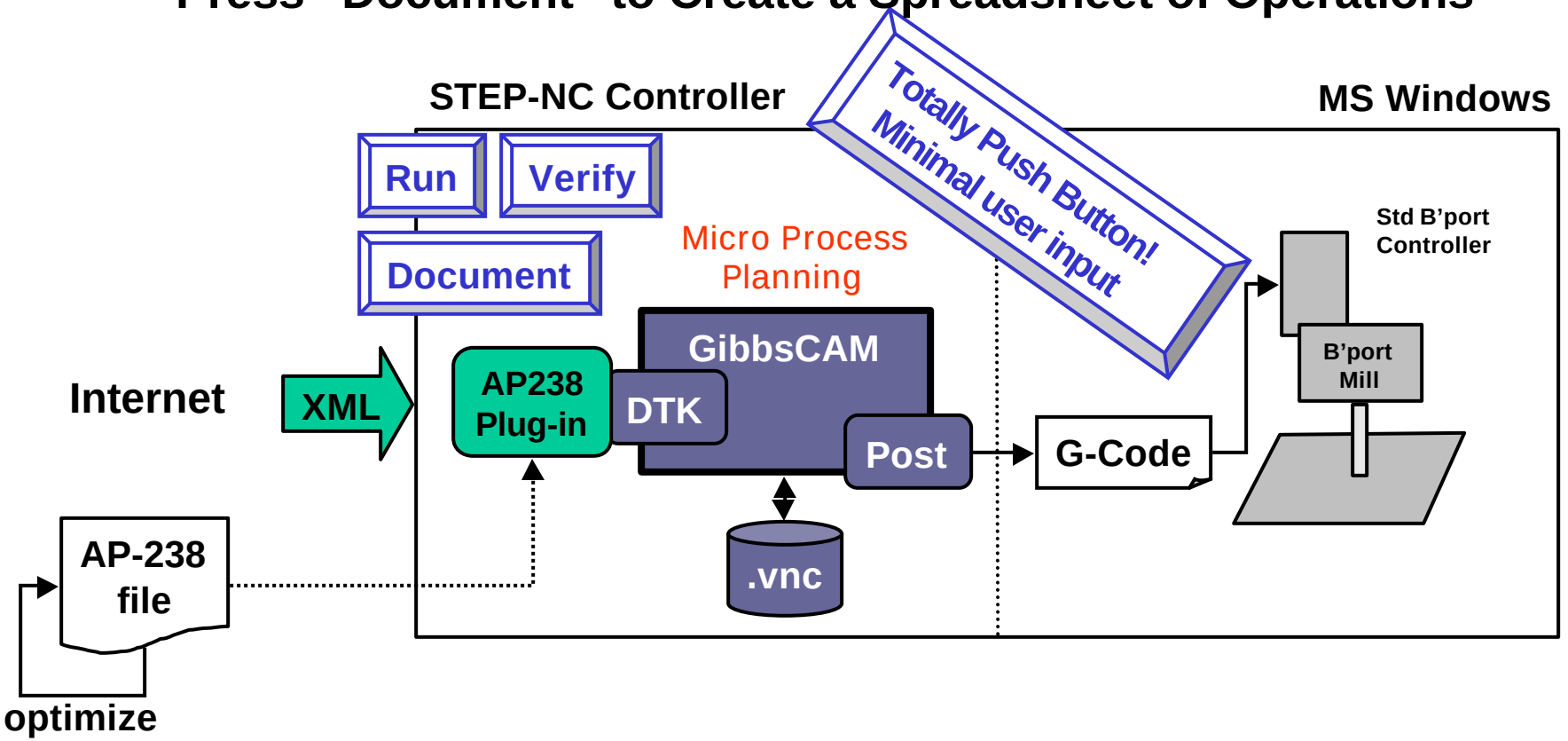
- **Bridgeport Upgrade**
  - **NT Operating System (Software)**
  - **New Spindle Drive (SERCOS Compatible)**
  - **Upgrade Three Drives to SERCOS**
  - **Upgrade MDSI Controller Software**
  - **Switch to Profi Bus**
  - **ISA SERCOS PC Card, SST Profi Bus Card**
  - **New Computer (Intel Motherboard, Intel Pentium 3 Processor 256 mg-vram 20g Hard Drive)**
- **Obtain**
  - **Licenses**
  - **Internet Connections**
  - **Original ISA GRAF Files**

WHY IS THIS IMPORTANT

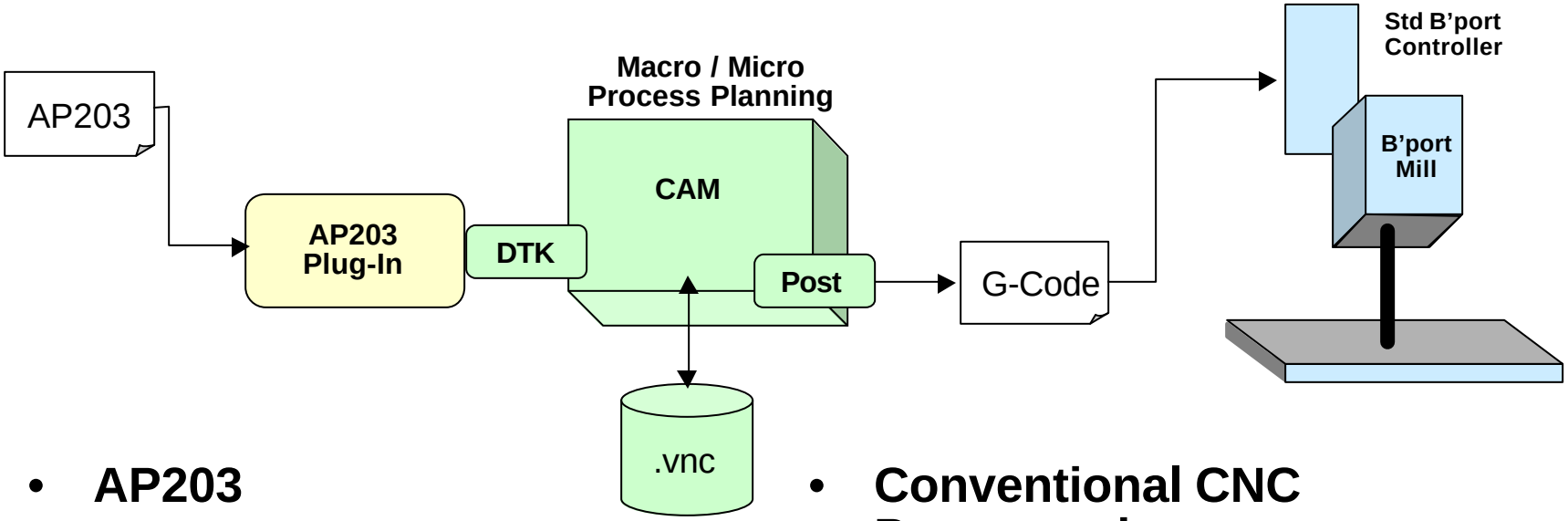
- **Demonstrate Three Kinds of Manufacturing Features being Cut on a Milling Machine**
  - **Demonstrate AP 203 (Design) to CAM System to M/G Codes to Machine**
    - **Significance - STEP AP 203 (Design) will Input to CAM**
- **Demonstrate to AP 238 (Step NC) to CAM to M/G Codes to Machine**
  - **Significance - Faster, More Flexible Set-Up using STEP NC**
- **Demonstrate AP 203 (Design) to AP 238 (Manufacturing) to CAM to OMAC Controller on Machine**
  - **Significance - Design and Manufacturing Integration to Open Modular Controller Eliminating M/G Codes**

GDLS DEMONSTRATION

- **STEP-NC Enable a Legacy Bridgeport Controller**
  - **Press "Run" to Make the Part**
  - **Press "Verify" to Check Tool Paths for Collisions**
  - **Press "Document" to Create a Spreadsheet of Operations**



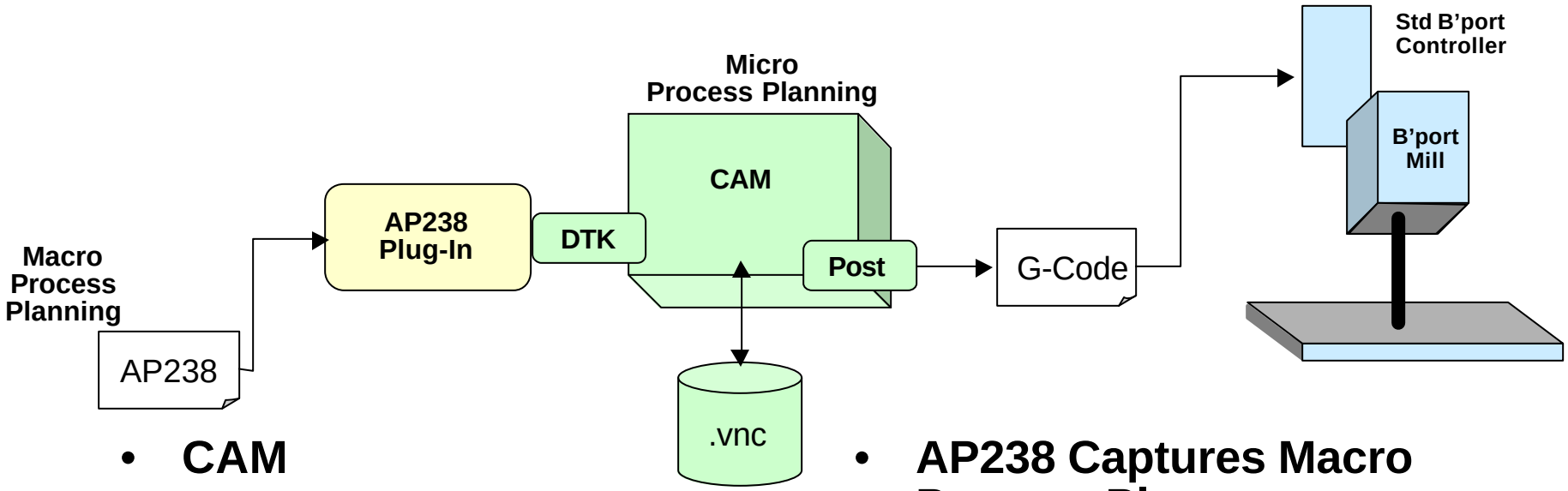
SCENARIO 1
AP203 ---> CAM ---> G- CODE



- **AP203**
  - **ISO Standard**
  - **B-Rep Geometry**
- **CAM**
  - **Machining Strategy**
  - **Toolpath Generation**
  - **CNC via Posted G-Code**

- **Conventional CNC Programming**
- **Proprietary G-Code**
- **Machine Tool Downstream**

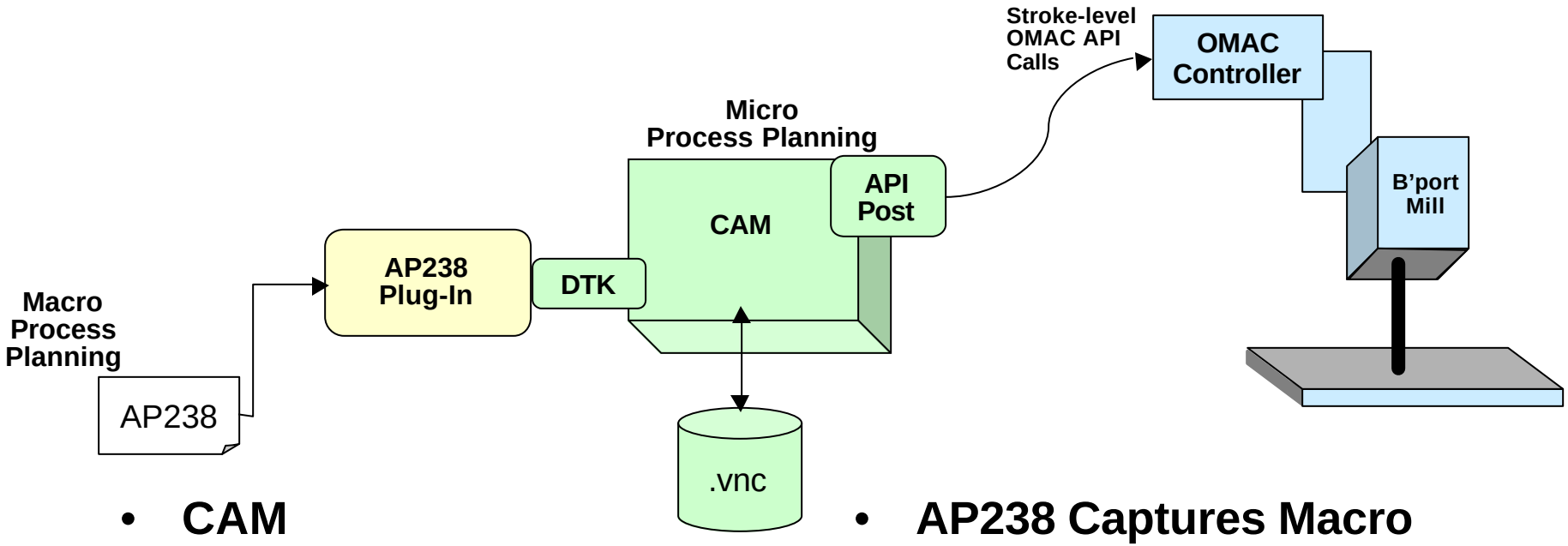
SCENARIO 2
AP238 ---> CAM ---> G- CODE



- **CAM**
  - **Toolpath Generation**
  - **CNC via Posted G-Code**

- **AP238 Captures Macro Process Plan**
- **Automated Toolpath Generation**
- **Conventional G-Code**

SCENARIO 3
AP238 ---> CAM ---> OMAC API



- **CAM**
  - **Toolpath Generation**
  - **CNC via OMAC API**

- **AP238 Captures Macro Process Plan**
- **Automated Toolpath Generation**
- **CNC Software Integration**

THE FUTURE

- **Develop an Integrated Manufacturing Environment Using (ISO) International Standards**
- **Initiate Limited Production Using a Machine Center at the GDLS Scranton Pennsylvania Plant**
- **Move Process to Additional GDLS Sites**

STEP NC / OMAC PRESS INTEREST

DATE	PUBLICATION	TITLE
2001 November	Manufacturing Engineering	Moving Toward the e-Factory
2001 May	American Machinist	The Ultimate STEP
2001 April	Modern Machine Shop	Feature Recognition – The Missing Link to Automated CAM
2001 April	Injection Moulding Magazine	E-Capable CNC Gains Ground
2001 March	Industry Week	The Next STEP
2001 February	NASA Tech Briefs (Applications Brief)	New User Interface for NASA System Simulation
2001 January	Manufacturing Engineering	STEP Into NC
2000 September	Manufacturing Automation	STEP Tools Advances Product Data Exchange in Manufacturing
2000 November	American Machinist (Technology Trends)	Revealing the Next STEP
2000 July	Machine Design	What You Should Know About STEP

JOINT LOGISTICS COMMANDERS
JOINT AERONAUTICAL COMMANDERS' GROUP
DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AERONAUTICAL SYSTEMS CENTER (AFMC)
1865 FOURTH STREET, ROOM 208
WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433-7128

8 MAY 2002

MEMORANDUM FOR THE AIR FORCE ACQUISITION EXECUTIVE
NAVY ACQUISITION EXECUTIVE
ARMY ACQUISITION EXECUTIVE

SUBJECT: Strategy for Product Data throughout the Life Cycle

1. Last year, we evaluated the benefits of standardizing on common product data exchange requirements. In particular, we were interested in standards that would allow engineering data developed under one automated design tool to be read and manipulated by design teams using different automated tools. We determined the existing ISO 10303 (STandard for Exchange of Product model data – STEP) met our military aeronautical requirements and that it was widely used by the commercial aerospace community. As a result, we have approved the use of STEP throughout our commands. Since STEP is a standard with many applications beyond aerospace (e.g., it is required in Navy shipbuilding), we encourage you to consider its use in other sectors.

2. Our implementation approach will be to use STEP in new aerospace system designs and major modifications to existing systems unless either the cognizant PEO or Systems Commander approves a waiver. The services have agreed and hence its use should be considered mandatory. Where a business case supports this, we are also encouraging the use of STEP for legacy systems.

3. The use of STEP will give us the greatest flexibility to take advantage of new computer design and support tools, but the real benefit to our services will be seen in reduced cost and cycle time, and in improved supportability. I would be pleased to arrange a briefing on STEP and our intended implementation, if you would like.

4. My point of contact for this subject is Mr. James Arnold, ASC/ENSM, DSN 785-9883, email: James.Arnold@wpafb.af.mil.

RICHARD V. REYNOLDS
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Attachment:
ISO 10303 Point Paper

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